

A Brief Description of the Supercell Detection Index¹

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The supercell detection index (hereafter, SDI) was devised to help forecasters in the 2005 NSSL-SPC spring forecast experiment with dealing with the large amount of information available from high resolution forecast models. Some participants in the program may not be familiar with the structures of modeled supercell from cloud-resolving simulations. SDI was developed to help identify storms within the model forecasts that have the dynamical character of supercells. SDI is based on the Doswell and Burgess (1993) that the primary dynamical property of a supercell updraft is a persistent, deep mesocyclone. We also use concepts from Droegemeier et al. (1993) that attempts to measure the “supercell-ness” of a storm by computing the correlation between the storm’s updraft and vertical vorticity. We use their computational methodology here, with some slight modifications, to detect supercells within the storm-scale forecast model output.

We wish to measure two things. To measure the dynamical character, we compute a layer-averaged correlation between vertical velocity and vertical vorticity (which is the relative vorticity, excluding the earth’s rotation and hereafter ζ). Second, we are trying to categorize the “significance” of the storm rotation by scaling the correlation coefficient by the local value of ζ . Therefore small values of the SDI mean low correlation and/or low values of ζ , high values indicate large correlation values ($r > 0.6$) of correlation and/or large values of ζ . Importantly, values of ζ are resolution dependent. From cloud modeling studies on a 2 km horizontal mesh significant values of ζ are $\sim |0.01 \text{ s}^{-1}|$.

The correlation coefficient is computed via Droegemeier et al. (1993),

$$\rho = \frac{\langle w' \zeta' \rangle}{\left(\langle w'^2 \rangle \langle \zeta'^2 \rangle \right)^{1/2}} \quad (1)$$

This requires knowing what the mean values of w and ζ are in some region in order to create the perturbations. Experimentation with cloud model output indicates that choosing a local 3-D “slab” centered on the grid point that is 20 km on each side and 4 km deep yields an acceptable parameter. The calculation is centered on $z = 3.5 \text{ km}$ in the vertical. The mean of w and ζ is computed from the series of points, perturbations calculated, and then the correlation is obtained from (1). The final calculation is obtained via,

$$SDI^1_{i,j} = \left[\frac{\langle w' \zeta' \rangle}{\left(\langle w'^2 \rangle \langle \zeta'^2 \rangle \right)^{1/2}} \right]_{i,j} \times \bar{\zeta}_{i,j} \quad (2)$$

The overbar on ζ indicates a vertical average in the column centered on the point. Rough estimates from the cloud model tests are that a minimal threshold for supercells is $\sim |0.0003 \text{ s}^{-1}|$, and that values greater than $|0.003 \text{ s}^{-1}|$ are significant. This quantity, called **SDI¹** actually indicates regions of updraft and downdraft (given by the sign of **SDI¹**) because the quantity is scaled by ζ , which is of the same sign as the mean value of ζ in the 3D slab. Therefore regions of updraft correlated with either positive or negative ζ show positive, and regions of downdraft correlated with either positive or negative ζ show as negative.

To help highlight regions of rotating updrafts, it was decided to generate a second SDI field computed only where there is updraft. This second index, **SDI²** is computed in a similar manner as **SDI¹** except that it is only non-zero in regions where $w > 0$, and it is scaled by the magnitude of ζ . This means that regions of positive **SDI²** are regions of cyclonic updrafts, and regions of negative **SDI²** are regions of anticyclonic updrafts.

¹ The real title is: **A Brief Description of the Supercell Detection Index and Use of Color #30** (see Jack Kain).

² Dave Dowell and Kim Elmore also contributed to this work.

Examples

We thought it might be helpful to show some examples from idealized cloud model simulations as to what these fields might look like. We will show the reflectivity, vertical velocity at $z \sim 1\text{ km}$, and then show both SDI indices. The simulations are run at 2 km horizontal resolution in order to be similar to the WRF 2 km runs.

Case 1

This is a case where there is large CAPE ($> 3000 \text{ J kg}^{-1}$) and large vertical shear, especially at low-levels, but it have low relative humidity in the boundary layer. Several cells were triggered along a north-south line. The simulation develops a NE-SW line of storms with some embedded rotating updrafts and at the southern end of the line a supercell storm develops.

See Figures 1-4.

Case 2

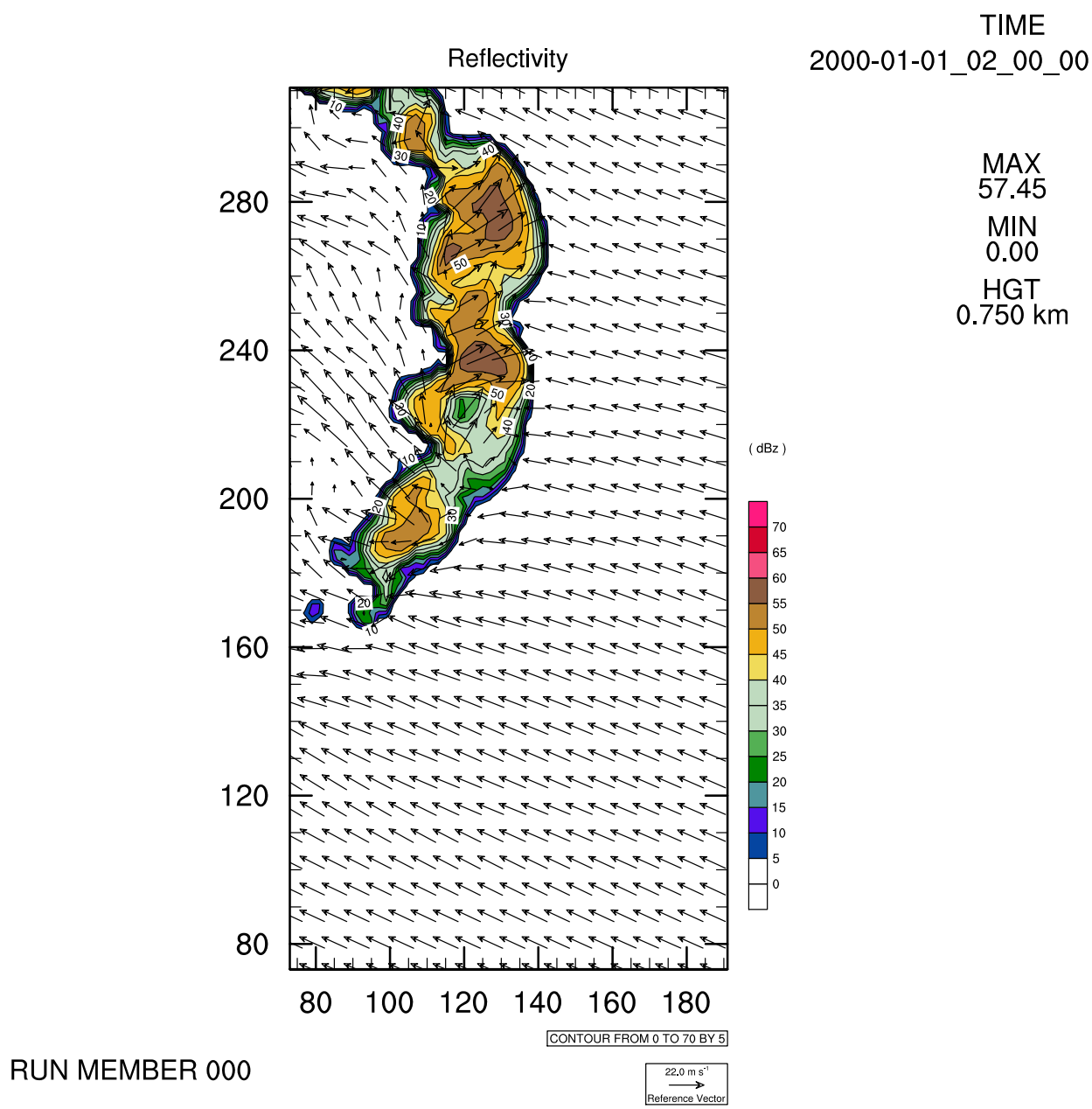
This simulation is the “classic” 20 May 1977 simulation that has been used (too often) over the past 20 years or so. A single storm is triggered, and you can see the typical structure that has been documented in both the modeling and observational literature.

See Figures 5-8.

References

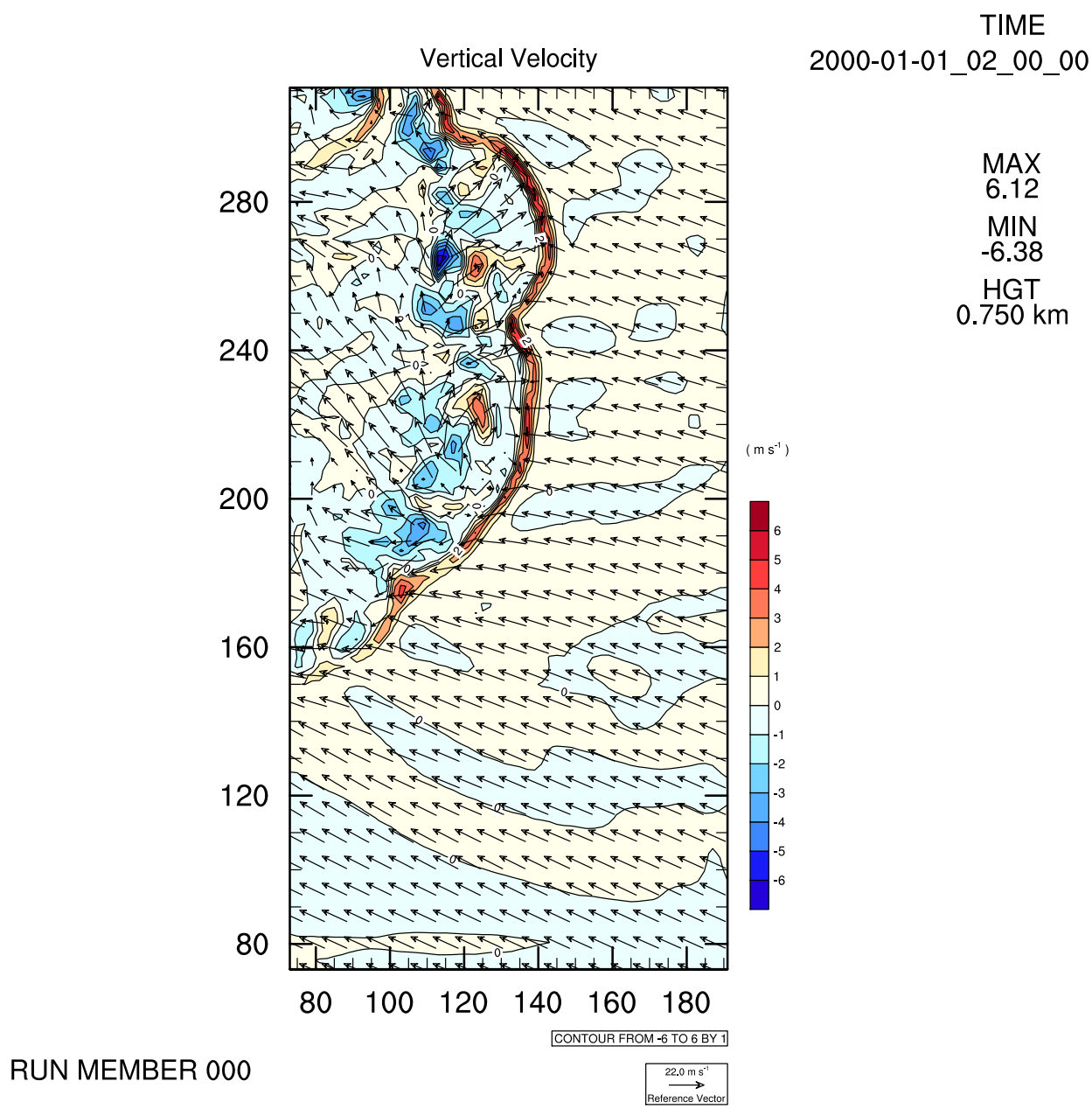
Kelvin K. Droegemeier, Steven M. Lazarus and Robert Davies-Jones. 1993: **The Influence of Helicity on Numerically Simulated Convective Storms.** *Monthly Weather Review*: Vol. 121, No. 7, pp. 2005–2029.

Doswell, C.A. III and D.W. Burgess, 1993: Tornadoes and tornadic storms: **A review of conceptual models.** *The Tornado: Its Structure, Dynamics, Prediction, and Hazards* (Church et al., eds). Amer. Geophys. Union, Geophys. Monogr. 79, 161-172.



RUN MEMBER 000

Figure 1: DBZ for squall line



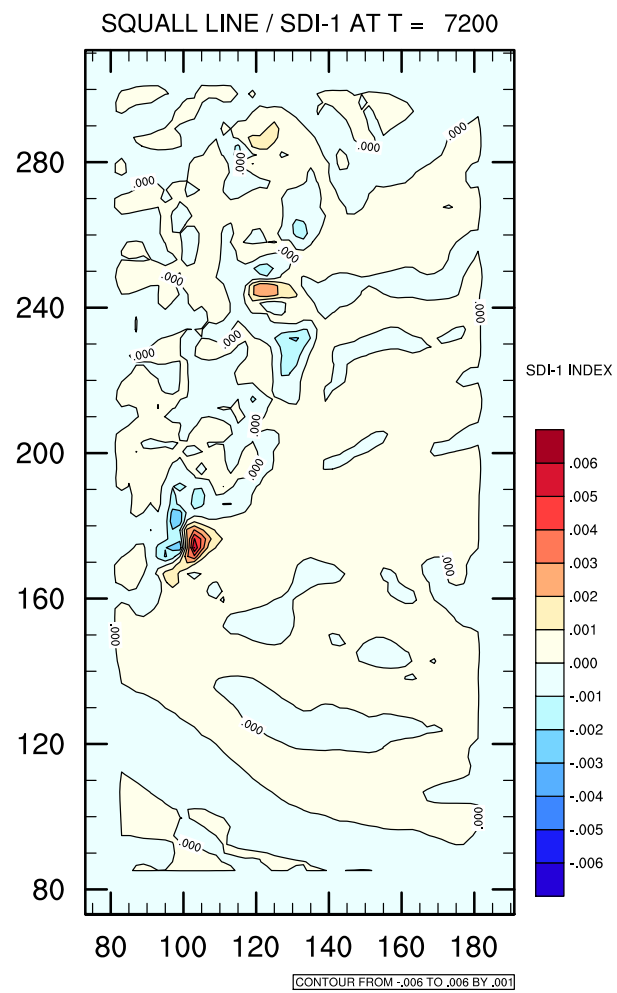


Figure 3: SDI-1 for squall line

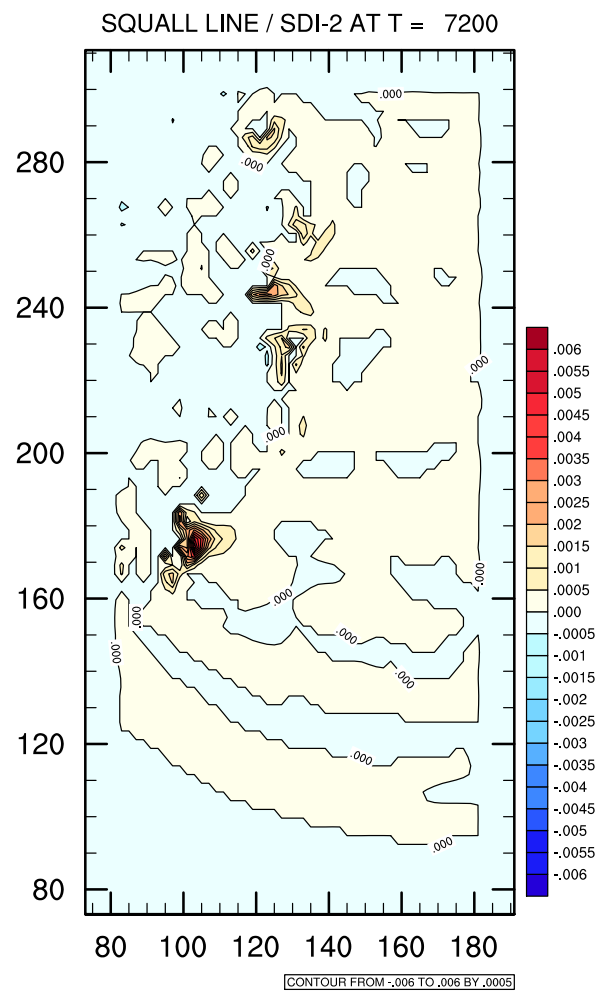


Figure 4: SDI-2 for squall line

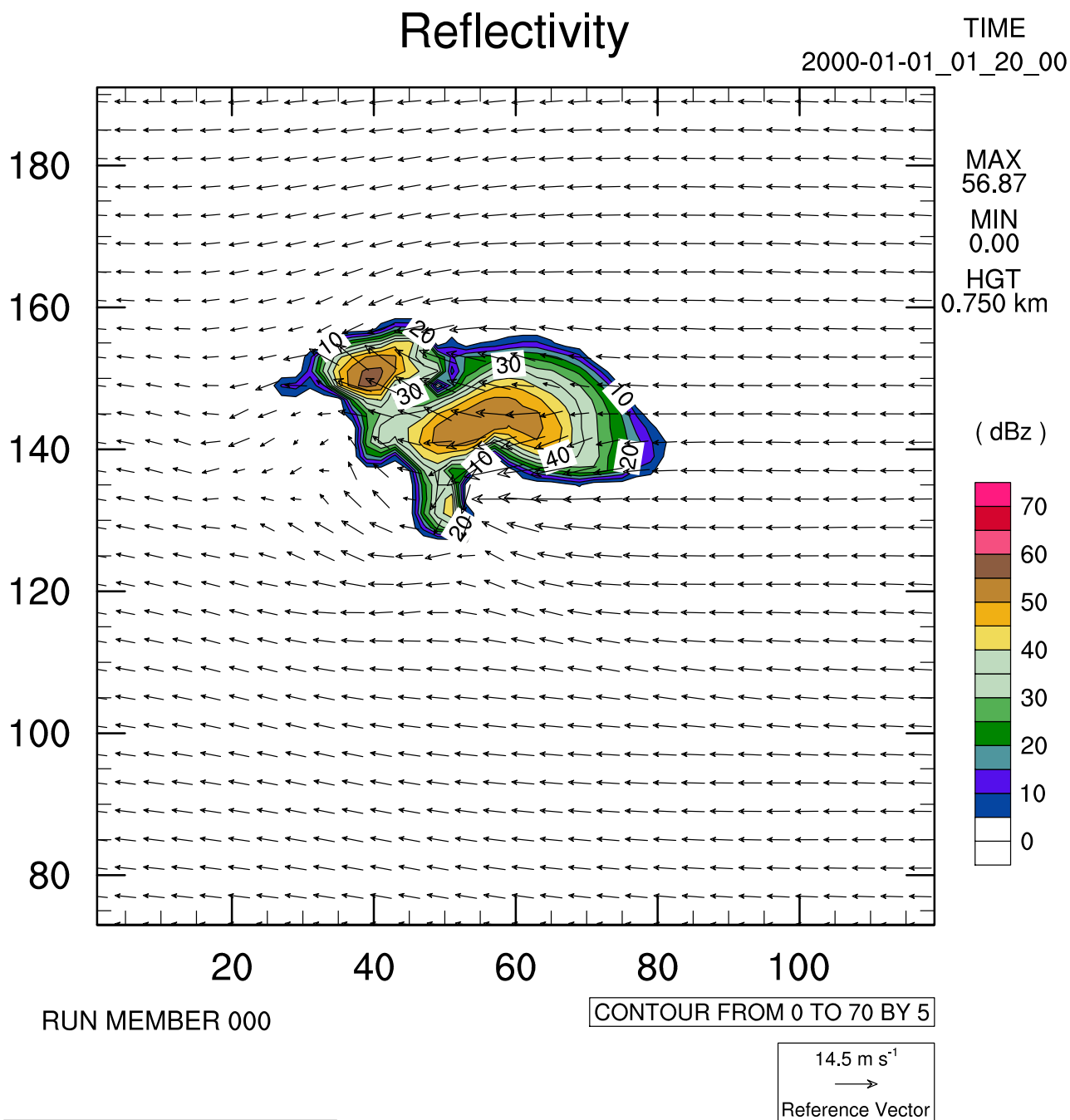


Figure 5: 20 May storm - Reflectivity

Vertical Velocity

TIME
2000-01-01_01_20_00

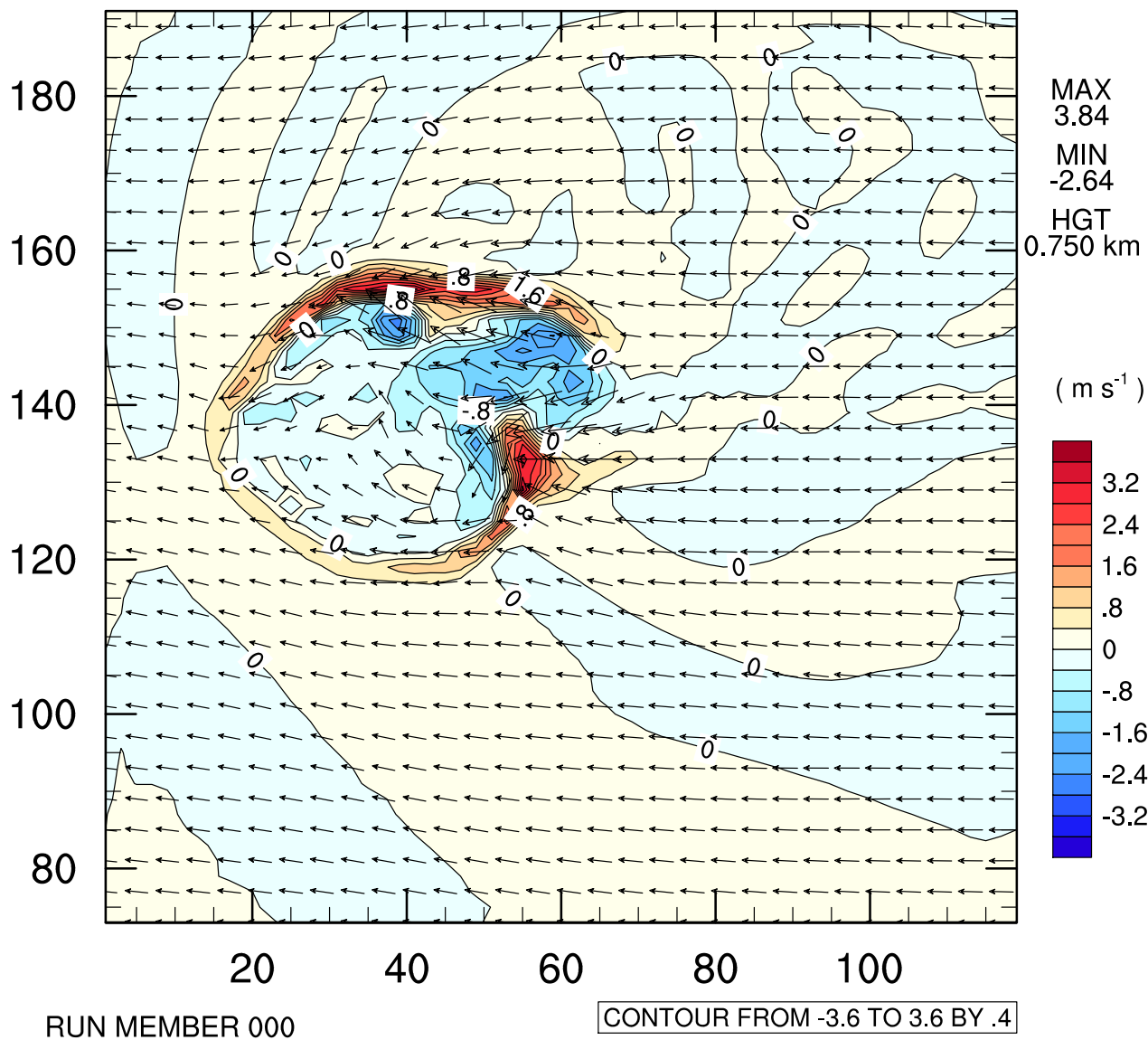


Figure 6: 20 May storm - vertical velocity

SUPERCCELL / SDI-1 AT T = 4800

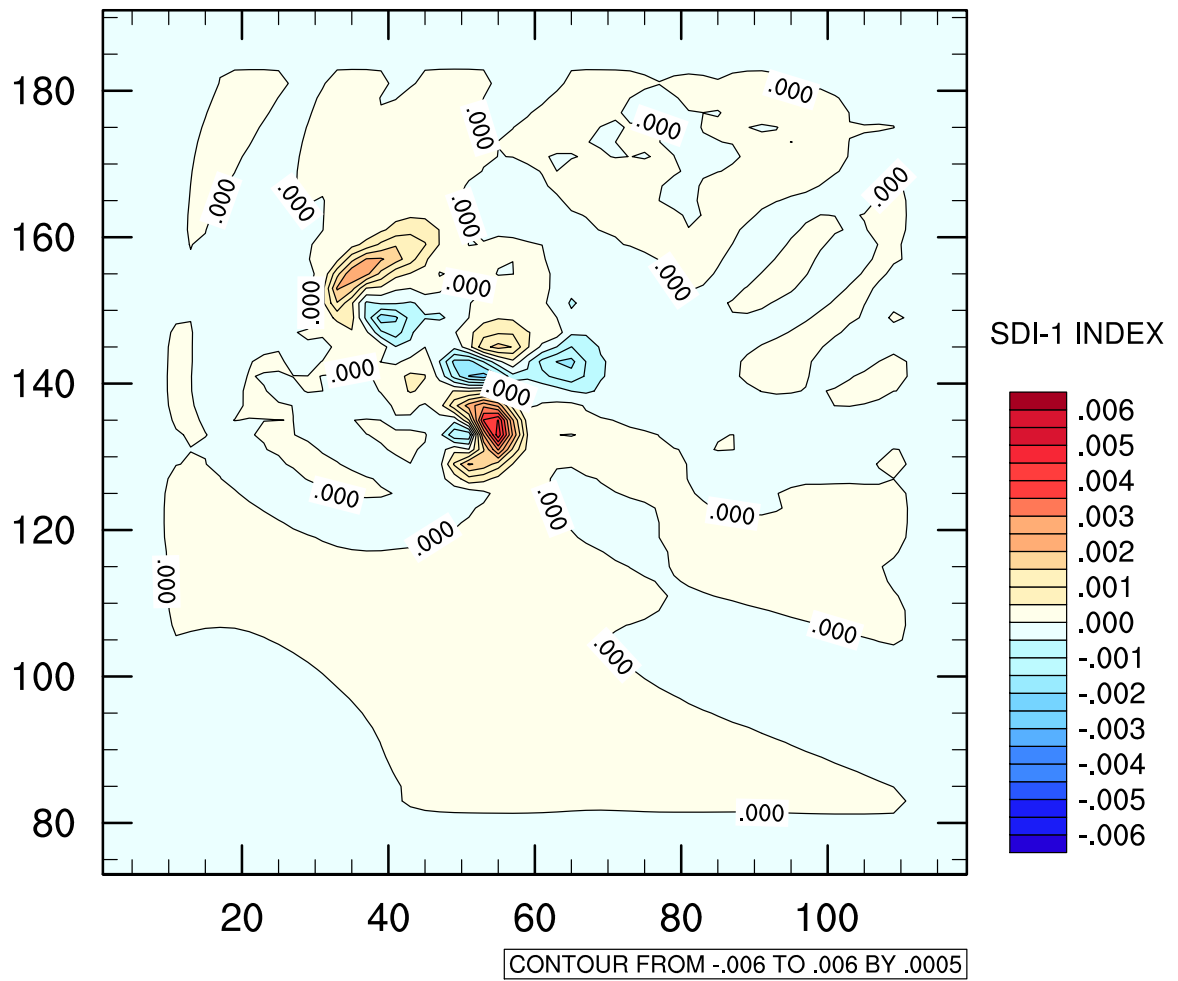


Figure 7: 20 May storm - SDI-1

SUPERCCELL / SDI-2 AT T = 4800

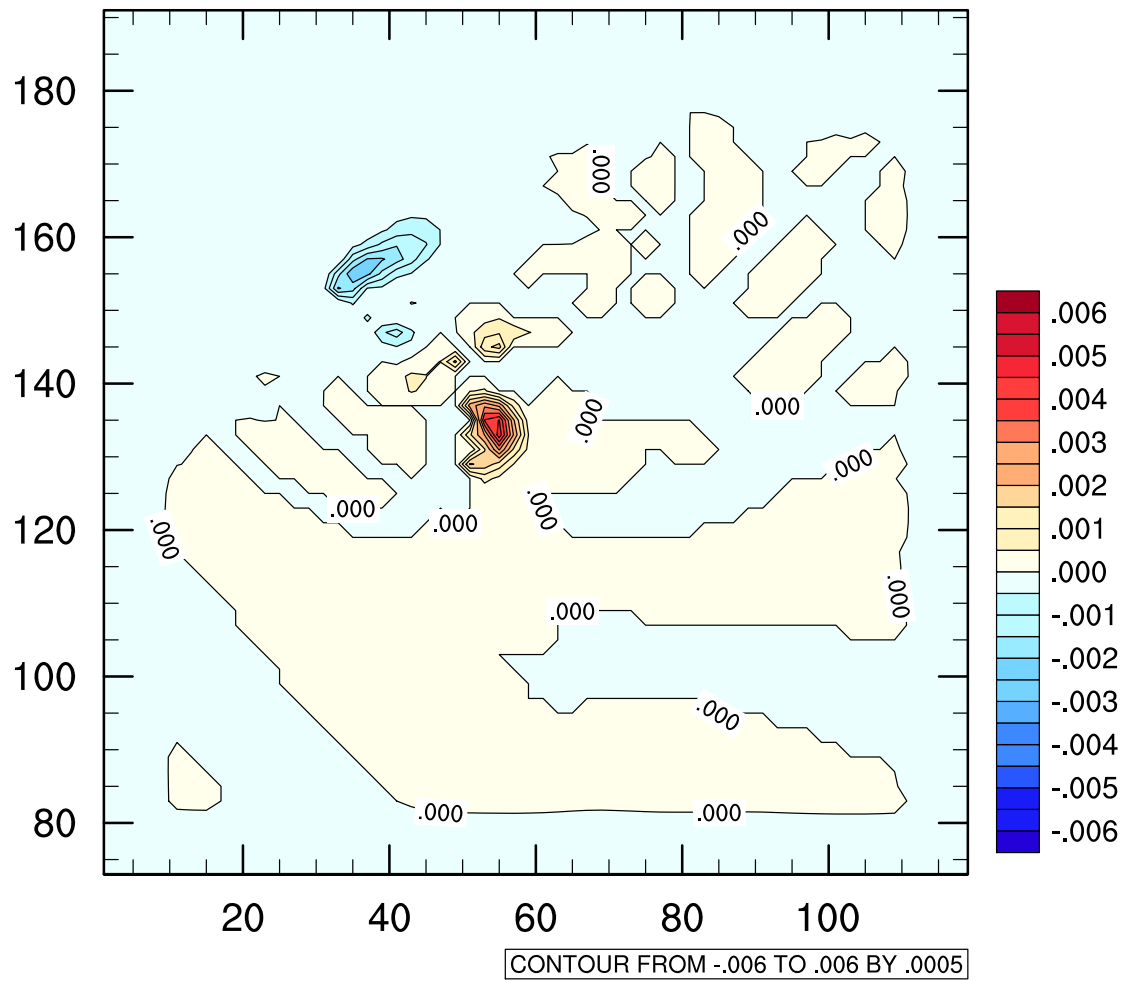


Figure 8: 20 May storm - SDI-2